Renal cortical and medullar oxygenation changes after oxygen challenge: evaluation with BOLD MRI.

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Introduction:
Renal medulla functions in hypoxic milieu and is susceptible to changes in blood flow and blood oxygenation (1). Studies have shown decrease in oxygenation level of renal medulla in animal models of chronic renal failure using invasive oxygen probes (2, 3). Several investigators have non-invasively studied oxygenation with BOLD MRI in human kidneys. These studies have assessed renal R2* values and some have used challenges such as Lasix injection and hydration/dehydration to evaluate changes in renal oxygenation (4-7). Our objective was to evaluate changes in R2* values of cortex and medulla using oxygen challenge in subjects with normal renal function, which to our knowledge has never been described before.

Methods:
This is an IRB approved prospective study on 7 subjects (4 male, 3 female, mean age 51 y) with normal renal function (mean GFR 91 ml/min/1.73m2, range 71 -118 ml/mim/1.73m2), who underwent BOLD MRI using 2 different 1.5T clinical systems (Avanto and Symphony, Siemens Medical Solutions). We used coronal T2* GRE with TR 80/TE 1- 40 (Avanto) and TR 232/TE 4.9-24.7 (Symphony), FOV 300-366 x 400-450, matrix 126-208 x 256, slice thickness 10 mm, acquisition time: 20 sec. per slice, 3 - 4 slices though the kidneys before and after approximately 20 min. of administration of 100% oxygen (10L/min) through a nasal canula. We calculated T2* and R2* (1/T2* in sec^{-1}) values on a commercial workstation by placing ROIs over the cortex and medulla in the upper, middle and lower pole of both kidneys before and after oxygen administration. ROIs were also placed over the psoas muscles (used as control). Values were averaged for each patient. We calculated ΔR2* = [(R2* before O2 - R2* during O2)/R2* before O2*100%] for cortex, medulla, and muscle. R2* and ΔR2* values were compared between cortex, medulla and muscle.

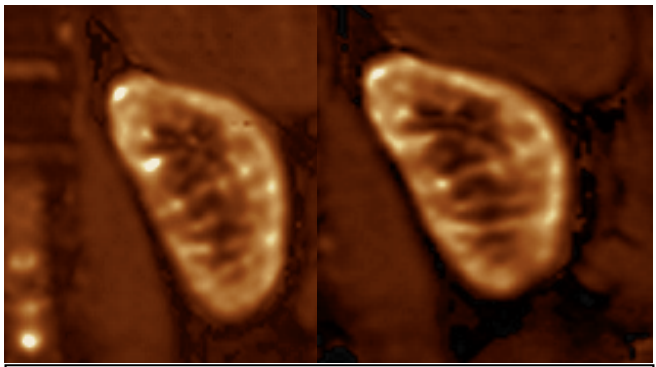
Results (Table):
R2* values of cortex and medulla were statistically different at baseline and during O2 inhalation. There was a significant increase in T2* and a decrease in R2* values (with increased ΔR2*) both in cortex and medulla, however significantly higher for the medulla (Fig.). There was no difference in ΔR2* for muscle.

	Cortex	Medulla	Muscle	p2
R2* before O2	13.02 ± 0.89	25.54 ± 5.84	36.92 ± 1.00	0.0003
R2* after O2	12.70 ± 0.73	21.86 ± 4.75	37.44 ± 1.35	0.0007
p1	0.032	0.0005	0.1345	
Δ R2* (%)	2.40 ± 2.80	12.25 ± 4.60	-1.38 ± 1.64	0.0004

R2* (sec^{-1}), p1: p pre- vs. post O2, p2: p cortex versus medulla

Discussion: Our preliminary study suggests that there is significant oxygenation of renal medulla compared to cortex in normal kidneys, after O2 challenge. This corroborates prior studies which used oxygen probes showing that the renal medulla is more hypoxic than cortex. This study demonstrates normal physiologic response after oxygen challenge in a noninvasive manner. BOLD MRI should be evaluated in patients with chronic renal failure as this may provide insight in pathophysiology of chronic renal failure. We hypothesize that the changes in R2* values of the medulla will be decreased in chronic renal function.

Conclusion: This preliminary study demonstrates the role of BOLD MRI with O2 challenge as a potential marker of renal function.



Renal BOLD T2* maps in a patient with normal renal function, before (left) and during O2 inhalation (right).
Δ R2* cortex=0.9%, Δ R2* medulla=11.6%

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